SEY properties of electron cloud mitigators at cryogenic temperatures

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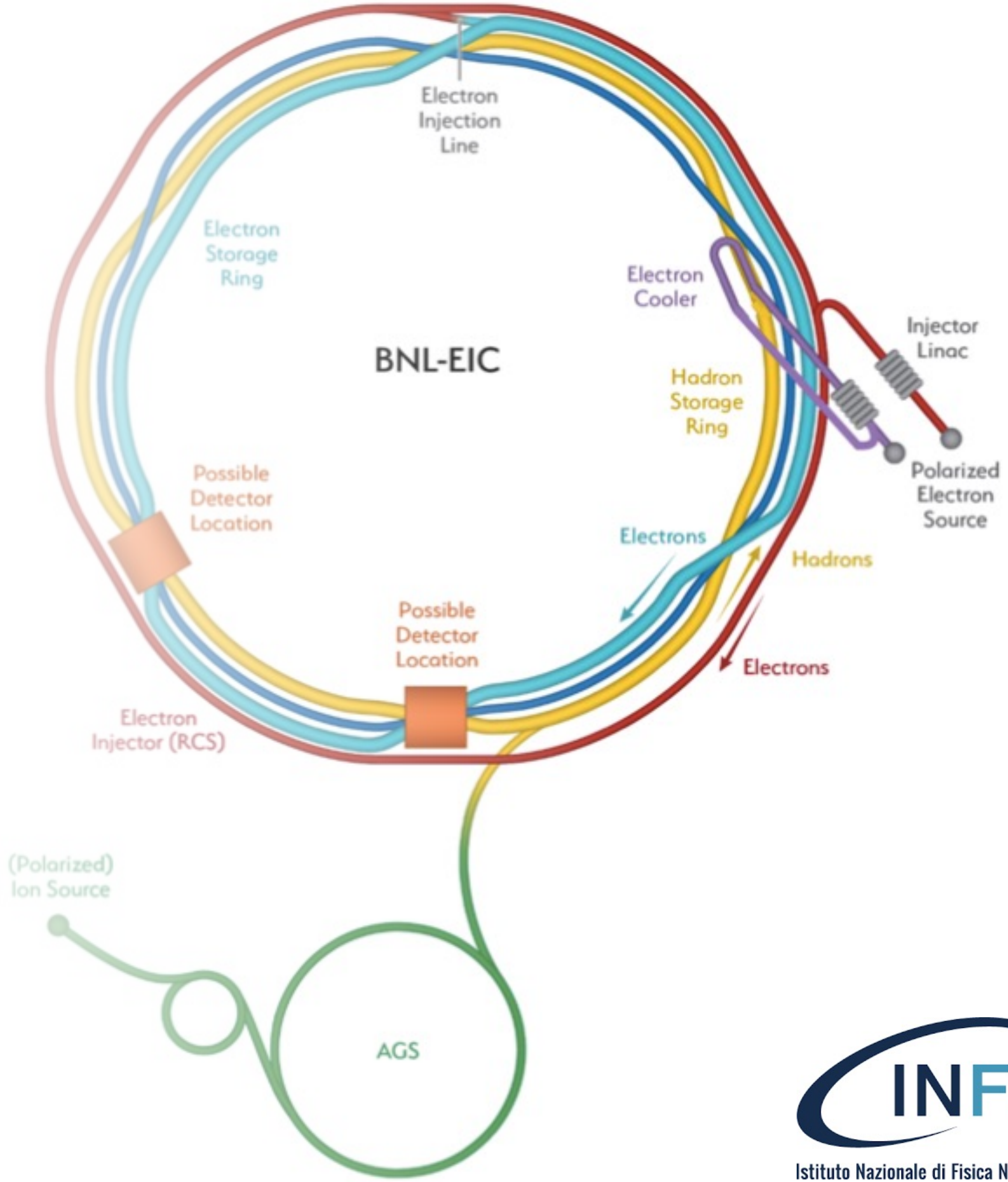

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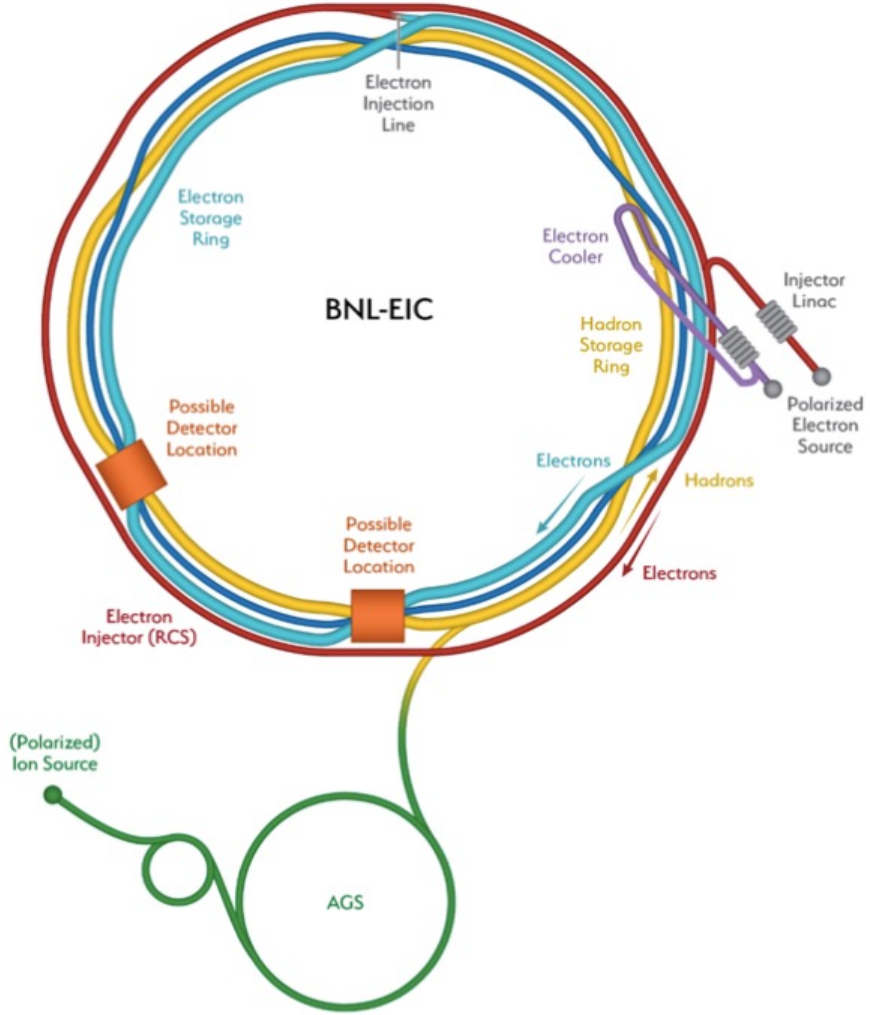


Table 1.1: Maximum luminosity parameters.

Parameter	hadron	electron
Center-of-mass energy [GeV]	104.9	
Energy [GeV]	275	10
Number of bunches	1160	
Particles per bunch [10^{10}]	6.9	17.2
Beam current [A]	1.0	2.5
Horizontal emittance [nm]	11.3	20.0
Vertical emittance [nm]	1.0	1.3
Horizontal β-function at IP β_x^* [cm]	80	45
Vertical β-function at IP β_y^* [cm]	7.2	5.6
Horizontal/Vertical fractional betatron tunes	0.228/0.210	0.08/0.06
Horizontal divergence at IP $\sigma_{x'}^*$ [mrad]	0.119	0.211
Vertical divergence at IP $\sigma_{y'}^*$ [mrad]	0.119	0.152
Horizontal beam-beam parameter ξ_x	0.012	0.072
Vertical beam-beam parameter ξ_y	0.012	0.1
IBS growth time longitudinal/horizontal [hr]	2.9/2.0	-
Synchrotron radiation power [MW]	-	9.0
Bunch length [cm]	6	0.7
Hourglass and crab reduction factor [17]	0.94	
Luminosity [10^{34} cm^{-2} s^{-1}]	1.0	

Introduction

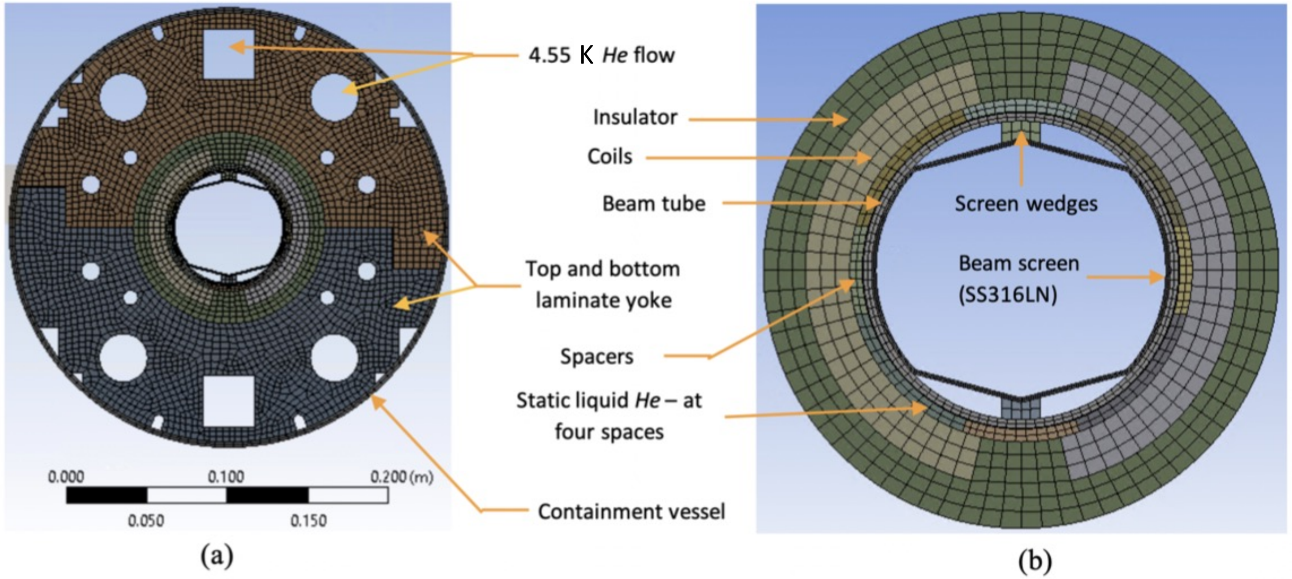
- The highest luminosity of $L = 1 \times 10^{34}$ cm^{-2} s^{-1} is achieved due to the large circulating electron and proton beam currents distributed over as many as 1160 bunches.
- The short spacing between the high-intensity bunches of the EIC favours the electron cloud build up which can lead to:
  - vacuum degradation;
  - beam instabilities;
  - emittance growth;
  - excessive heat load;
  - etc.

→ e-cloud mitigation is crucial

Introduction (Mitigation Strategy)

- In the non-cryogenic (warm) sections, the electron cloud can be mitigated by using non-evaporable getter (NEG) coating.

- To avoid high RW heating and electron cloud, a beam screen (BS) will be installed in the beampipe of the RHIC superconducting magnets.



EIC CDR 2021

EIC HSR beam screen

must ensure:

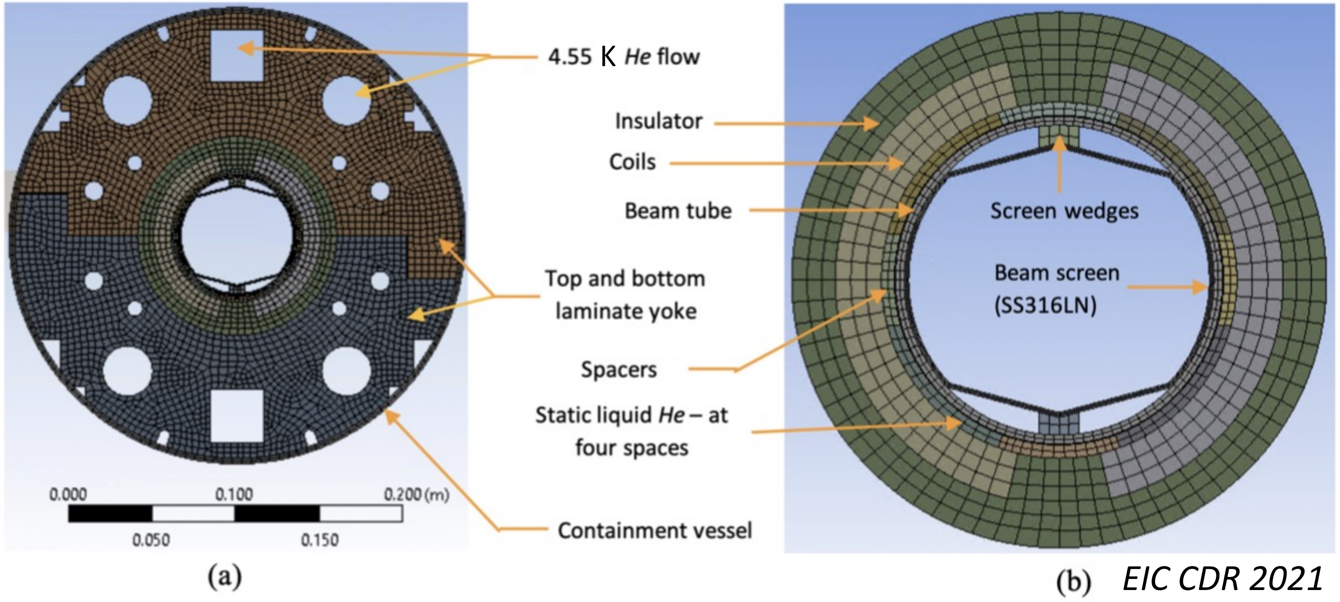
- Adequate vacuum level and stability.
- Low impedance to limit dynamic heat load and to avoid impedance-driven instabilities.
- The control of e-cloud build up.

EIC HSR beam screen

will made of:

- Non-magnetic 316LN stainless steel.

- Oxygen-free high-conductivity (OFHC) copper.



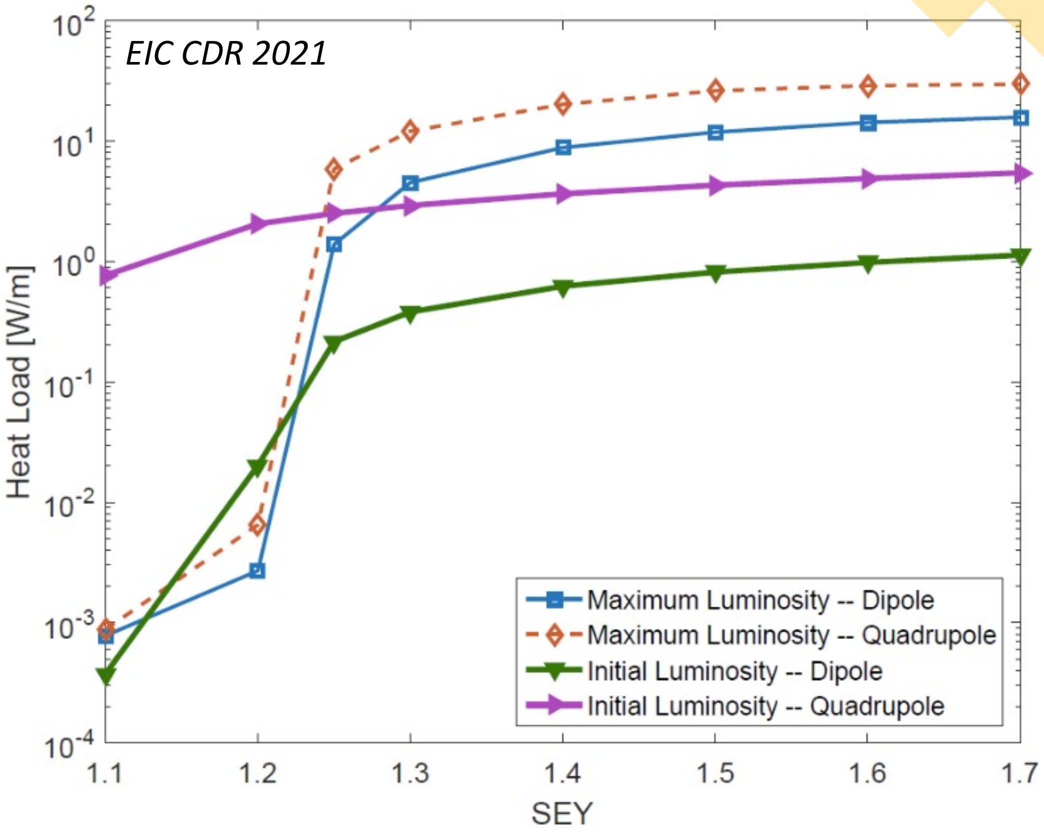
EIC CDR 2021

Heat Load on the BS (SS + OFHC copper)

- The OFHC copper has a conductivity that is several orders of magnitude larger than 316LN stainless steel at 4 K, <u>leading to smaller RW impedance and dynamic heat load expected from beam-induced currents.</u>

- The electron cloud starts for SEY values above 1.1.

e-cloud mitigator with SEY< 1.02

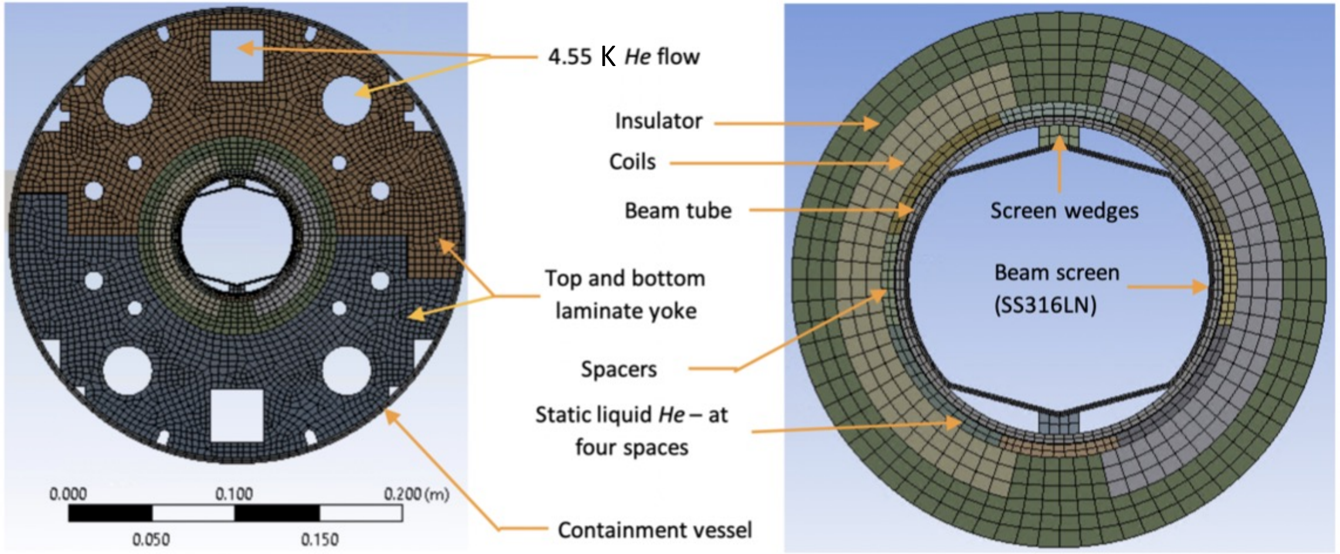


Heat load as a function of SEY for the EIC proton beams for initial and maximum luminosity scenarios

EIC HSR beam screen

will made of:

- Non-magnetic 316LN stainless steel.
- Oxygen-free high-conductivity (OFHC) copper.
- Low SEY coating. (a-C)



(a) (b) *EIC CDR 2021*

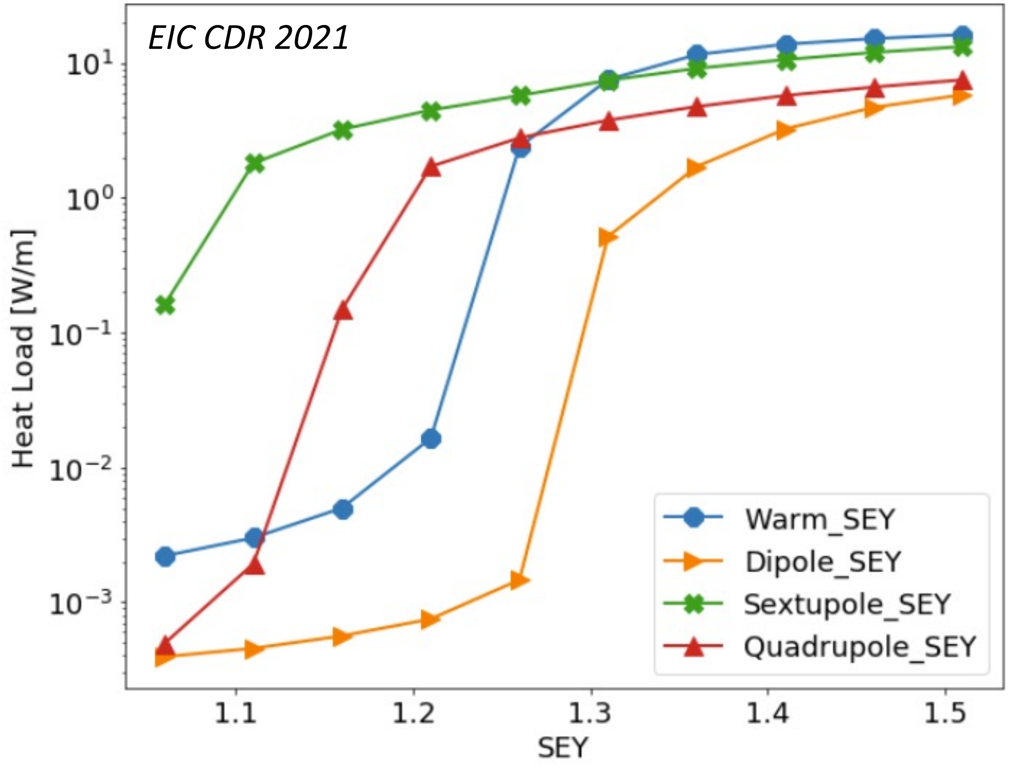
Heat Load on the BS (SS + OFHC Cu + a-C coating)

- a-C film deposited on the copper surface. (SEY < 1.02)

- <u>The thickness of the a-C film can have significant impact on the RW impedance.</u>

↓

Minimum Thickness of a-C coating

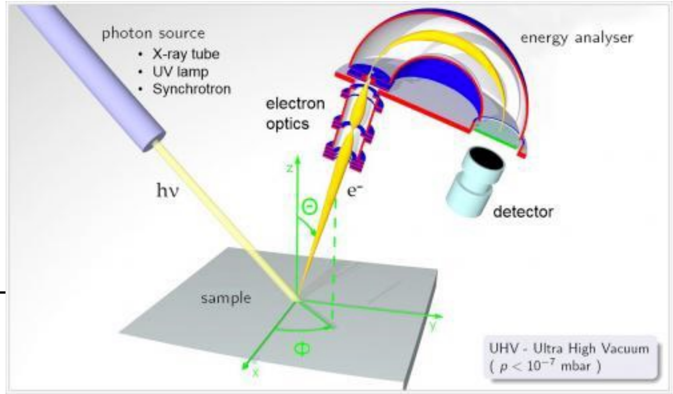


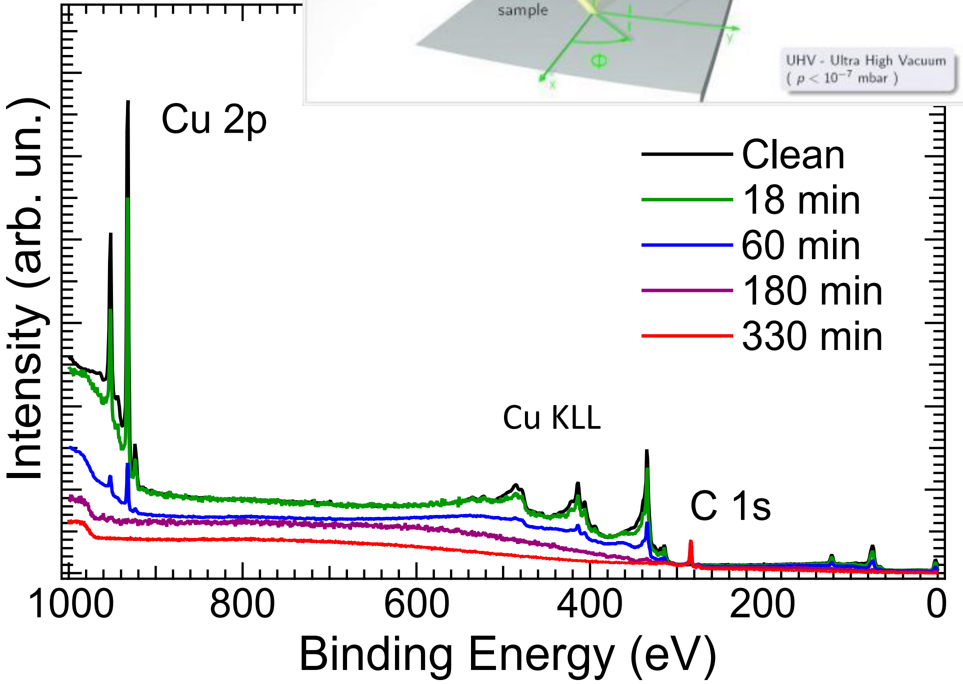
Heat load as function of SEY for maximum luminosity scenario including a beam offset of 14 mm.

Studies of SEY of Cu with thin a-C coating

thermal evaporation from graphite rod

XPS analysis
(Coverage Estimation)



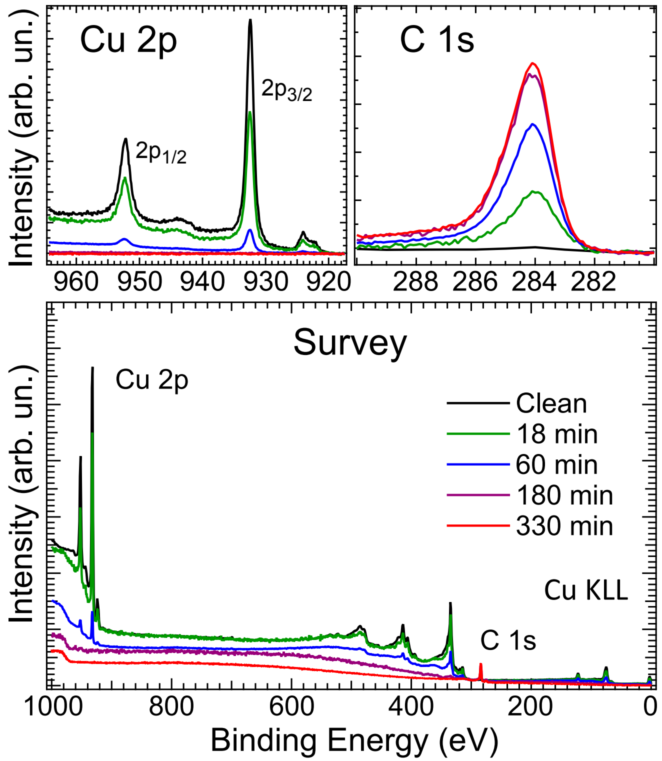


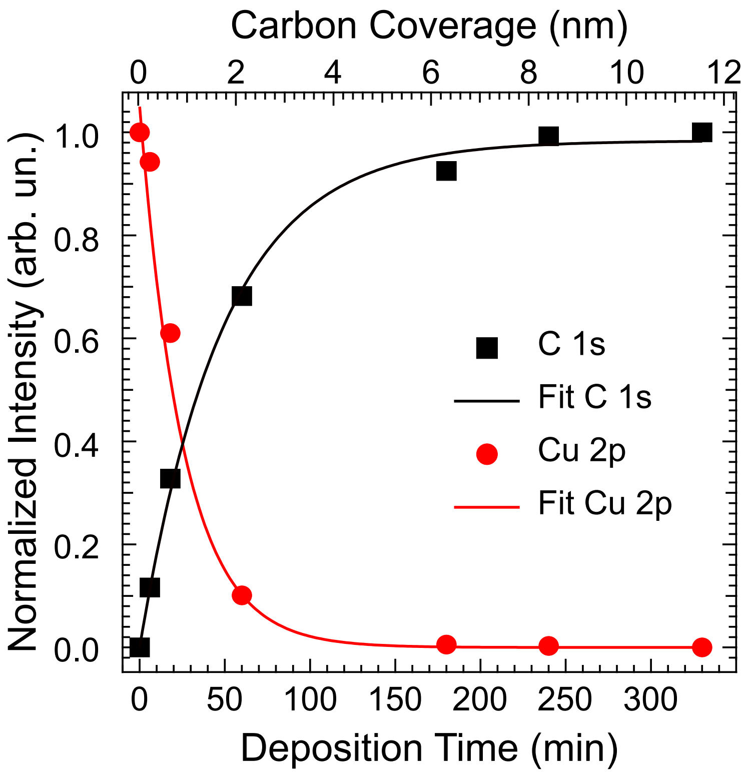
SEY measurements

Minimum thickness evaluation

Minimum thickness of a-C coating on Cu

XPS estimation of Coverage





Conversion of deposition time to Carbon Coverage (nm)

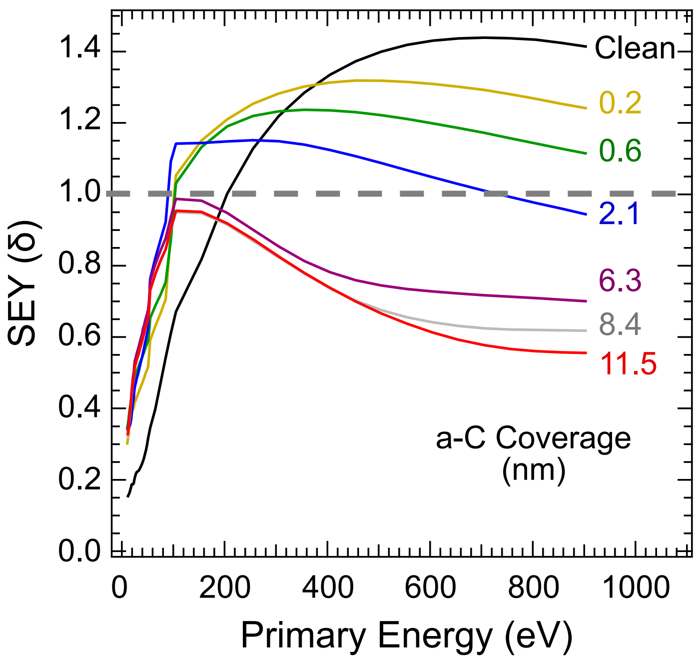
$$I_{Cu}^{C} = (I_{Cu,bulk}^{C})*\exp(-d/\lambda_{Cu,C})$$

$$I_{C}=I_{C,bulk}*(1-\exp(-d/\lambda_{C,C}))$$

M. Angelucci et. al; Phys. Rev. Research Rapid comm. 2, 032030(R) (2020)

Minimum thickness of a-C coating on Cu

SEY Evolution



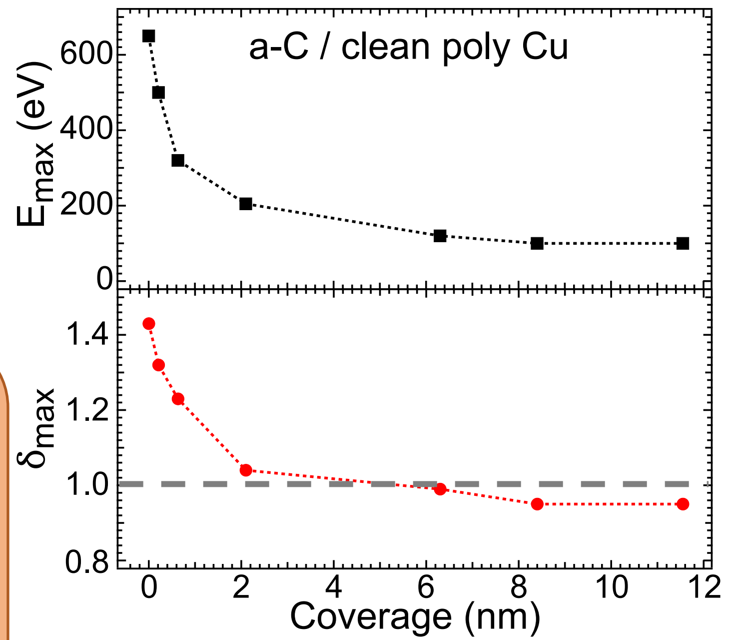
Low coverage (< 6 nm):

Strong SEY modification

High coverage (> 6 - 8 nm):

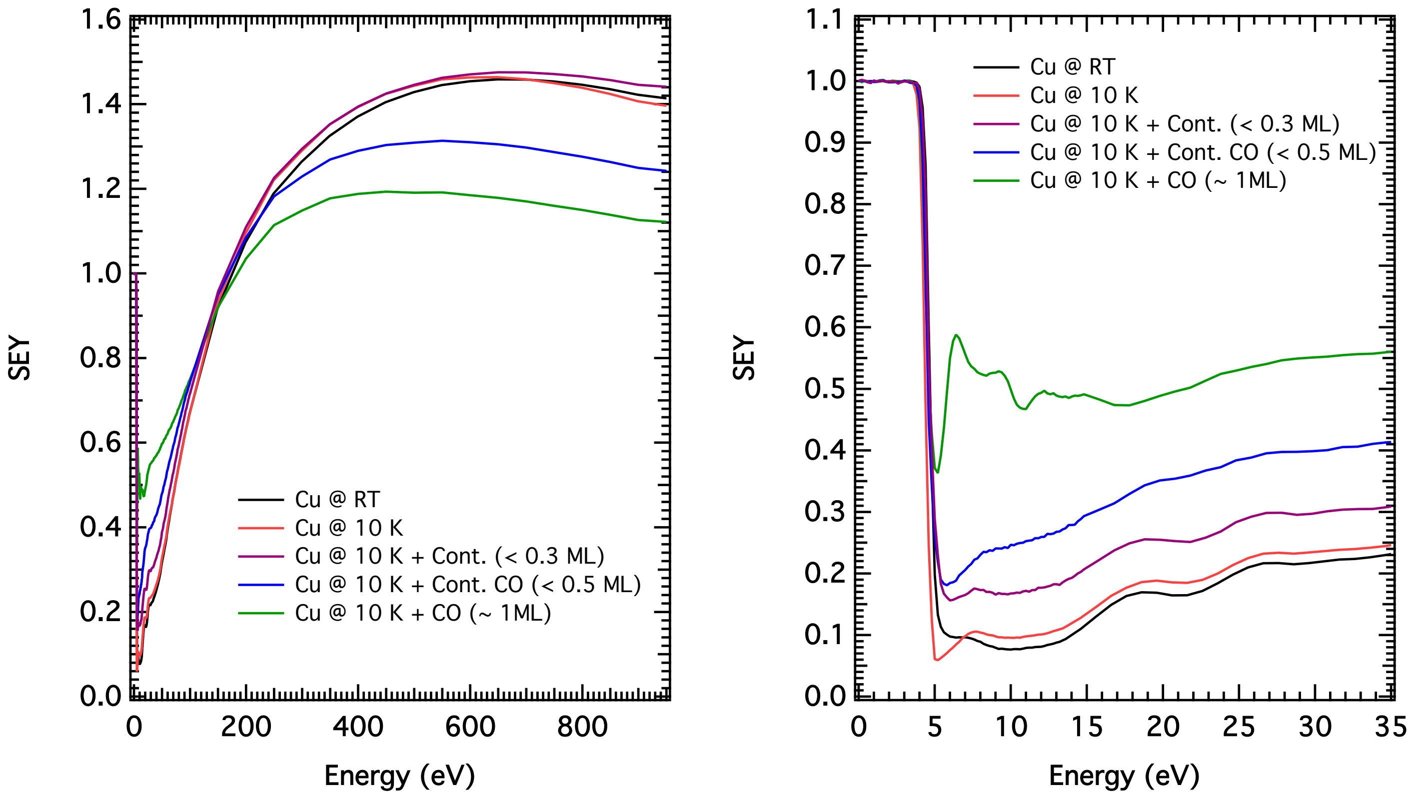
Stable δ_{max} <1

Low variation in the low (<50 eV) and high (>500 eV) regions



M. Angelucci et. al; Phys. Rev. Research Rapid comm. 2, 032030(R) (2020)

SEY variation at Cryogenic Temperature



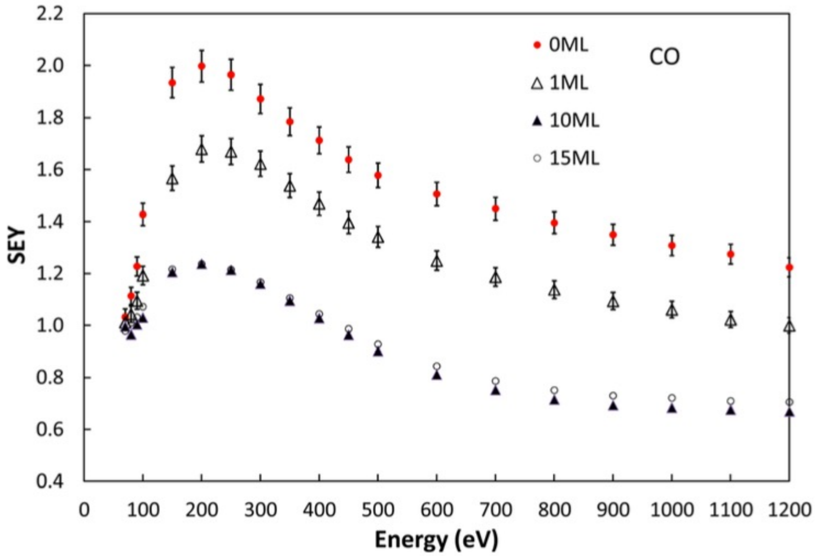
L. A. Gonzalez et al., AIP Adv. (2017)

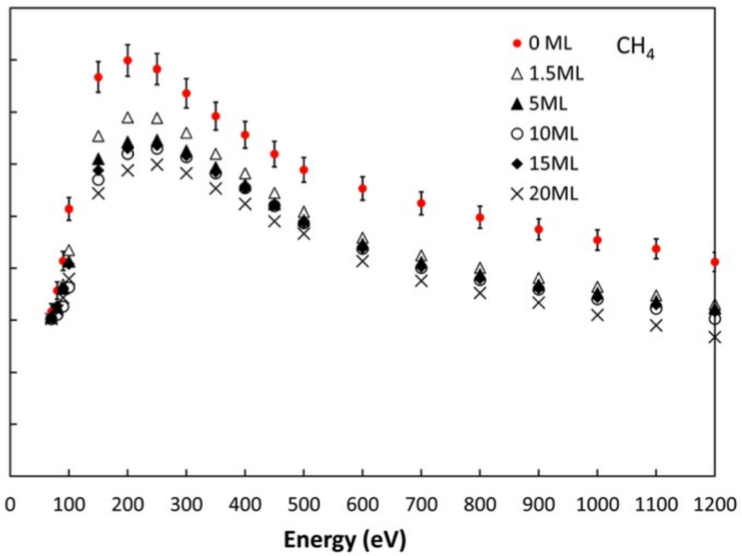
SEY is an intrinsic material property strongly sensitive to the surface composition and chemical state

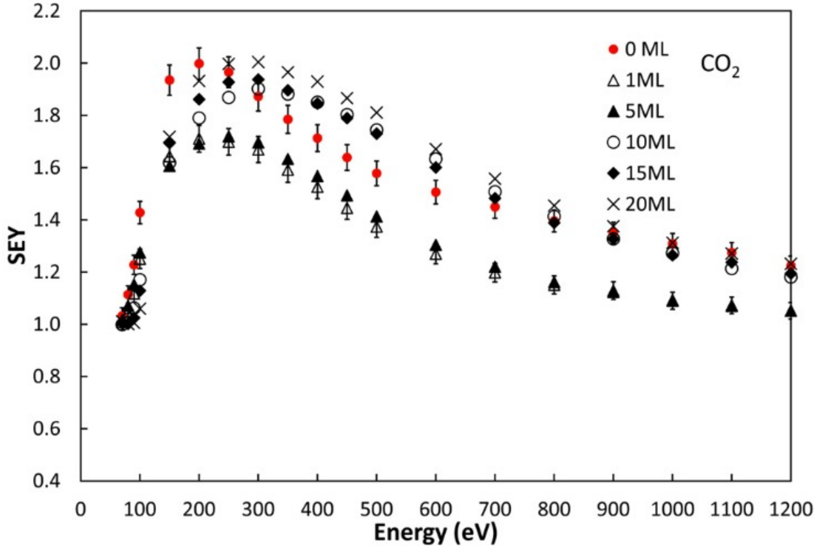
SEY of cryogenic surfaces influenced by gas physisorption:

- <u>Coverage (even at sub-monolayer)</u>

SEY variation at Cryogenic Temperature







SEY is an intrinsic material property strongly sensitive to the surface composition and chemical state

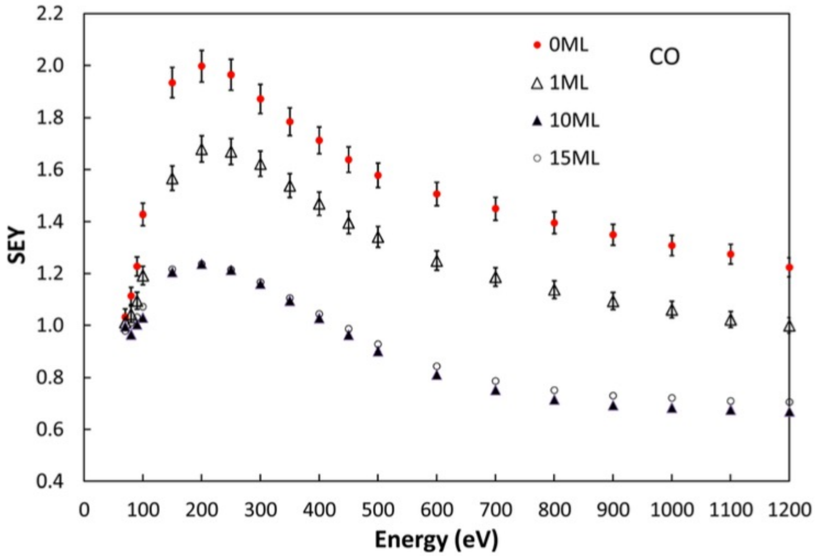
Adsorbed gas influences SEY

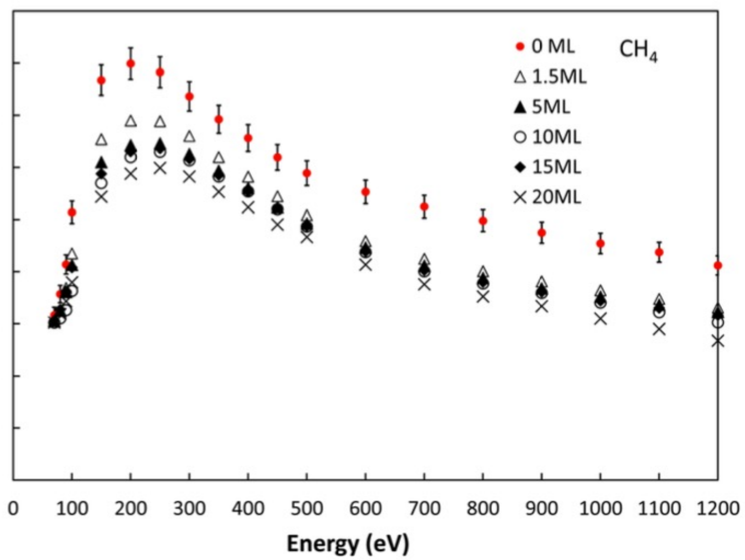
SEY of cryogenic surfaces influenced by gas physisorption:

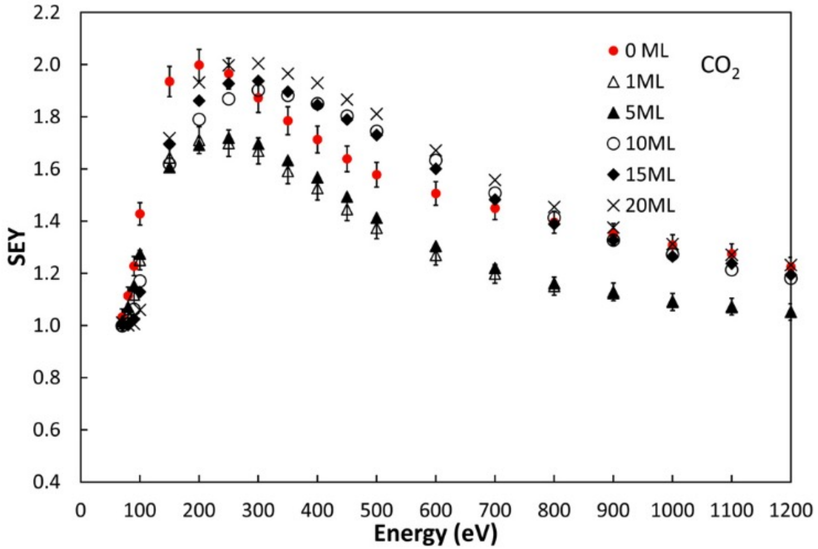
- Coverage (even at sub-monolayer)
- Gas Species

Kuzucan et al.,
J. Vac. Sci. Technol. A (2012)

SEY variation at Cryogenic Temperature







SEY is an intrinsic material property strongly sensitive to the surface composition and chemical state

SEY of cryogenic surfaces influenced by gas physisorption:

- Coverage (even at sub-monolayer)
- Gas Species

How is a-C thin film SEY modified by adsorbed gas?

Kuzucan et al.,
J. Vac. Sci. Technol. A (2012)

Thank You

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